# Influence of the focused ion beam parameters on the etching of planar nanosized multigraphene/SiC field emitters

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Nanoscale field emission structures are a promising element of nanoelectronics. The use of nanocarbon materials in field emission electronics contributes to improving the durability of the cathode, stability of emission and reduction of threshold voltages [1-3]. Multigraphene films obtained by the thermal destruction of silicon carbide in vacuum are considered in the work. This method is technologically efficient and allows one to obtain uniform multigraphene films suitable for electronic application. Semi-insulating silicon carbide was used as a substrate. The two-dimensional structure of the multigraphene film is used in the basis of the field emission nanostructure. The planar design of the field emission structure contributes to the emission of electrons from the end of the multigraphene film when a potential difference is applied. The field emission cathode was performed in the form of a point for increasing the form factor. Focused ion beams (FIB) of gallium were used to form field emission structures with a nanoscale interelectrode distance. The minimum interelectrode distance depended on the width of the ion beam.

The possibility of fabrication of planar field emission nanostructures based on multigraphene films on silicon carbide using FIB-technology is considered in this paper. Nova NanoLab 600 (FEI Company, Netherlands) ion-electron scanning microscope was used for etching experimental samples. Minimum currents (1-10 pA) were used to form the minimum possible interelectrode distance for this technology. An increase in current strength promotes an increase in lateral etching.

The possibility of applying FIB to fabricate planar emission nanostructures based on multigraphene on SiC and determining the effect of FIB-parameters on the etching of the structure were performed using a scanning probe microscope Solver P47 Pro (Nanotechnology MDT, Russia). Scanning of the FIB-processed areas allowed to determine the presence of etched areas and to estimate their depth. It was found that etching of planar field emission nanostructures at a current of 1 pA does not lead to a change in the depth of the treated area. An increase in current up to 10 pA becomes sufficient to initiate the etching process of a multigraphene film on the surface of silicon carbide. The etching depth increases with increasing etching time. The etching depth was considered sufficient when the silicon carbide was etched after the multigraphene film. The fulfillment of this condition is necessary for isolating the cathode from the anode.

Conductive probes were used for local studies of electrical properties of nanoscale structures. The pressure contact was located on the surface of the multigraphene film. The conductive probe was in contact with the investigated region. It was revealed that etched areas do not conduct electric current. This confirms that FIB-treated local sections of the multigraphene film are completely etched to semiinsulating silicon carbide. The contact of the conducting probe with the unetched area of the field emission cathode promoted the appearance of an emission current.

Thus, it is shown that fabrication of field emission structures with a nanoscale interelectrode distance is possible using FIB-technology. The use of a scanning probe microscope made it possible to determine the FIB-parameters for the fabrication of planar field emission structures, to monitor their geometric parameters and to carry out local measurements of electrical parameters.

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